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Transonic Interference Reduction by Limited Ventilation Wall Panels

(NASA-CR-175039) TRANSONIC INTERFERENCE REDUCTION BY LIMITED VENTILATION WALL PANELS Final Report (Ohio State Univ.) 15 p Avail: NTIS HC A02/MF A01 CSCL 01A N87-29419 Unclas G3/02 0100027

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INTRODUCTION

In attempting to use a conventional subsonic wind tunnel having solid sidewalls into the transonic speed range, undesirable interference effects appear caused by model blockage and/or wave reflections. The speed at which such interference appears varies with the model size and with the angle-of-attack. Modifications to the tunnel, i.e. by increasing the size of the test section or adding ventilated walls may not be feasible for reasons of cost or available space. However it may be possible to replace parts of the walls of the test section with segments so designed as to eliminate the interference or to reduce it appreciably.

One such wind tunnel in question was the 12-inch by 12-inch high-speed icing tunnel of the National Aeronautical Establishment at Ottawa, Canada, as it existed in 1981 when the NASA Lewis Research Center expressed interest in conducting an icing study on airfoil sections typical of application to helicopters. The tunnel system appeared capable of a speed range up to Mach number 0.7; however, the use of model chords of about 6 inches would clearly result in excessive interference due to the solid walls of the test section. Relatively large access ports were available on the test section and there appeared to be some possibility of modifying those to reduce the interference.

An investigation into the feasibility of such a technique was undertaken at the Ohio State University Aeronautical and Astronautical Research Laboratory (OSU/AARL) using the 6-inch by 12-inch airfoil tunnel to model the situation. This tunnel has a two-dimensional configuration and uses perforated plates backed-up by independent plenum chambers for distances of 14 inches upstream and 20 inches downstream from the model mounting site. Model chords of 6 inches are normally used in tests at Mach numbers from 0.2 to 1.1; the interference is calibrated and of a very low level. Thus the NAE tunnel and anticipated models could be modelled exactly except for the width. The OSU/AARL tunnel was modified by replacing the perforated walls with solid plates with provision for inserting ventilated segments in the vicinity of the model, in the same relative location to the model as the access ports in the NAE facility. This report describes the configuration tested at OSU/AARL and that installed in the NAE icing tunnel ; some typical data are presented to document the characteristics of the revised test section.

WIND TUNNEL CONFIGURATIONS

The details of the circuit of the NAE wind tunnel are given in Figure 1. Figure 2 is a schematic of the test section showing the configuration of the access ports available on the top and the bottom of the tunnel as well as the perforated panels which were finally installed. The configuration tested in the OSU/AARL 6X12 in. tunnel is outlined in Figure 3; the width of the panel was that estimated to scale the port width on the NAE test section.

MODELS

The profile chosen for the study was the NACA-0012; it was to be used extensivelly in the rotor icing research program and, additionally, a large body of experimental data exists for that section. The models used in the two tunnels differed only in span,in correspondence to the widths of the tunnels; the chords of both were 6 inches.

TEST RESULTS

For reference purposes and to demonstrate the magnitude of the interference without wall ventilation, a few tests were conducted with solid walls throughout; the pressure distribution of Figure 4 was typical of supercritical flow. As expected the tunnel was choked at the model and the resulting surface pressure distribution was highly distorted. The theoretical code [1,2] is expected to give a fairly accurate estimation of the pressure distribution and of the shock location at the specified Mach number and attack angle in free air.

Several porous-plate configurations were tested in the OSU/AARL tunnel with that of Figure 3 showing the least interference over the range of interest. The data of Figures 5 and 6 are typical for subcritical and supercritical flows respectively. In all cases, reference was made to theoretical codes [1-3], to data from the OSU/AARL 6X22 in. airfoil tunnel and, in the supercritical case, to tests with a 6-inch chord model in the CALSPAN 8-foot transonic tunnel; to avoid confusion, the referenced data [4] are shown without symbols.

The perforated plate configuration was copied directly for the NAE wind tunnel installation. Typical pressure distributions for subcritical and supercritical flows are presented in Figures 7 and 8. In the latter instance, data are shown for a repeated run as well. On the basis of the comparison of the data with the theoretical prediction, the modification was considered as suitable for conducting model tests in the supercritical speed range.

CONCLUSIONS

The installation of a set of perforated plates backed-up by independent cavities in the test-section of a normally solid-walled subsonic wind tunnel resulted in the reduction of transonic wall interference to negligible levels. The modification permitted the use of the tunnel at Mach numbers up to 0.75, with a model chord-to-height ratio of 0.5 and at attack angles over the full range of interest, making possible an icing study of significance to helicopters [5,6].

REFERENCES

1. Bauer, F.; Garabedian, P.; Korn, D. and Jameson, A. Supercritical Wing Sections II, A Handbook, Lecture Notes in Economics and Mathematical Systems, Vol. 108, Springer-Verlag, New York, 1973.

2. Bauer, F.; Garabedian, P. and Korn, D. Supercritical Wing Sections III, A Handbook, Lecture Notes in Economics and Mathematical Systems, Vol. 150, Springer-Verlag, New York, 1977.

3. Smetana, F.O.; Summey, D.C.; Smith, N.S. and Carden, R.K. Light Aircraft Lift, Drag and Moment Prediction - A Review and Analysis. NASA CR 2523, 1975.

4. Lee, J.D., Gregorek, G.M. and Korkan, K.D. : Testing Techniques and Interference Evaluation in the OSU Transonic Airfoil Facility. AIAA-78-1118, July, 1978.

5. Fleming, R.J. and Lednicer, D.A. :High-Speed Ice Accretion on Rotorcraft Airfoils. NASA CR 3910, 1985, Lewis Research Center.

6. Fleming, R.J. and Lednicer, D.A. : Experimental Investigation of Ice Accretion on Rotorcraft Airfoils at High Speeds. AIAA-84-0183, Jan.,1984.

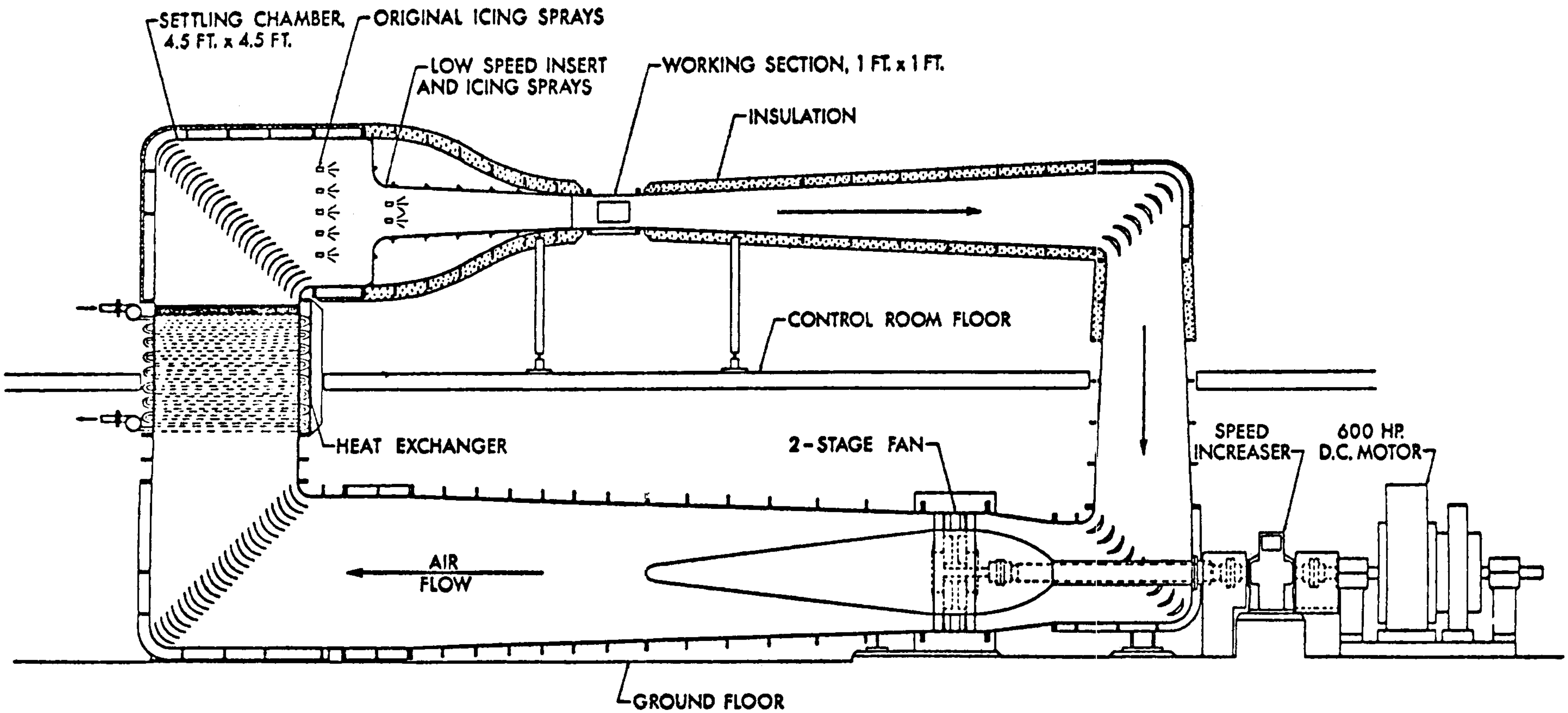

FIGURE 1. LAYOUT OF THE HIGH-SPEED ICING WIND TUNNEL AT THE CANADIAN NATIONAL RESEARCH ESTABLISHMENT IN OTTAWA

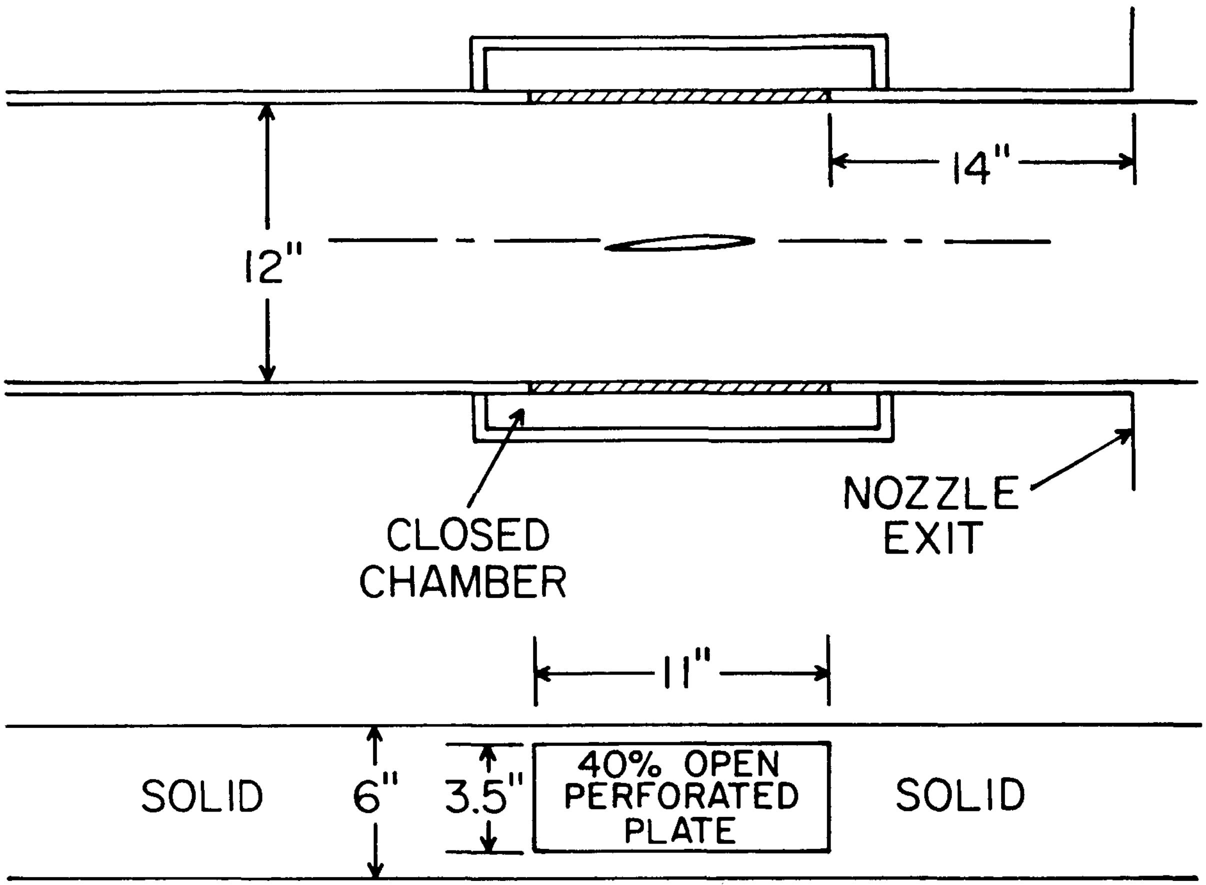

FIGURE 2. WALL CONFIGURATION TESTED IN THE OSU 6 X 12 IN. HIGH REYNOLDS NUMBER TRANSONIC WIND TUNNEL AS A SIMULATION OF THE PROPOSED MODIFICATION TO THE NAE HIGH SPEED ICING WIND TUNNEL

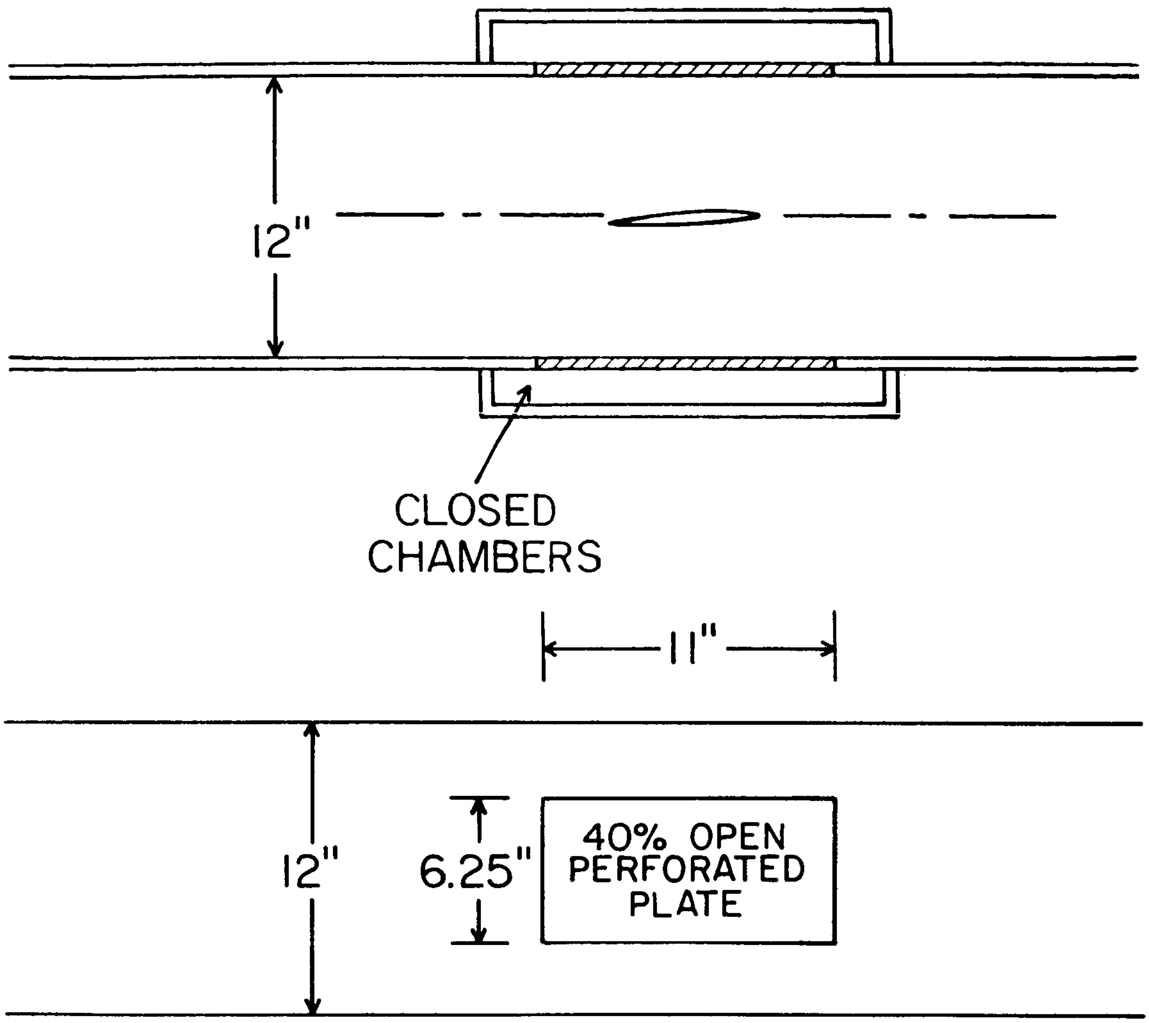

FIGURE 3. SECTION OF THE NAE HIGH SPEED ICING TUNNEL SHOWING THE VENTILATED PANELS PROPOSED AND TESTED.

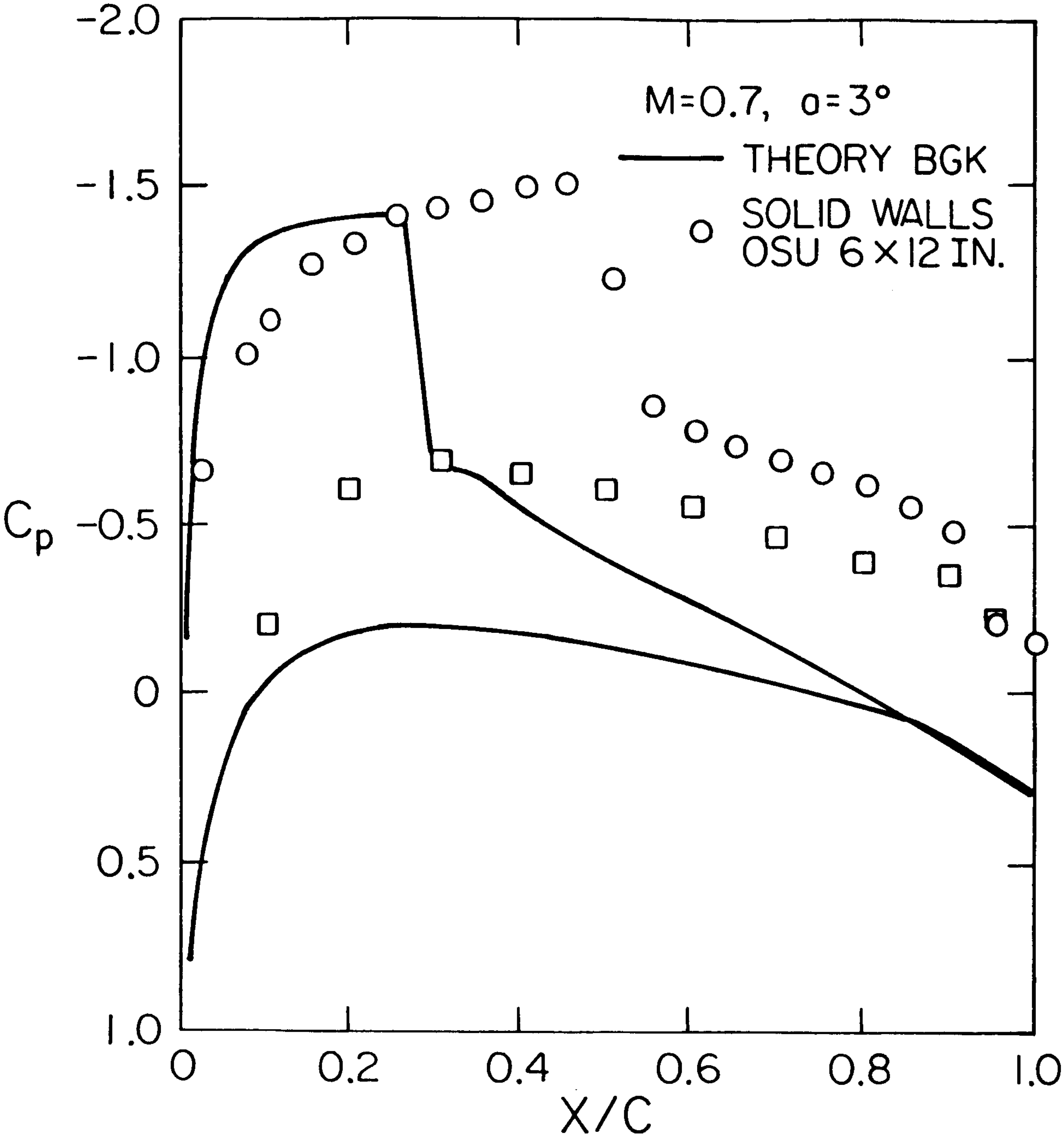

FIGURE 4. SURFACE PRESSURE DISTRIBUTIONS ON NACA-0012 MODEL SHOWING SOLID WALL INTERFERENCE IN SUPERCRITICAL FLOW. CHORD=6 IN.

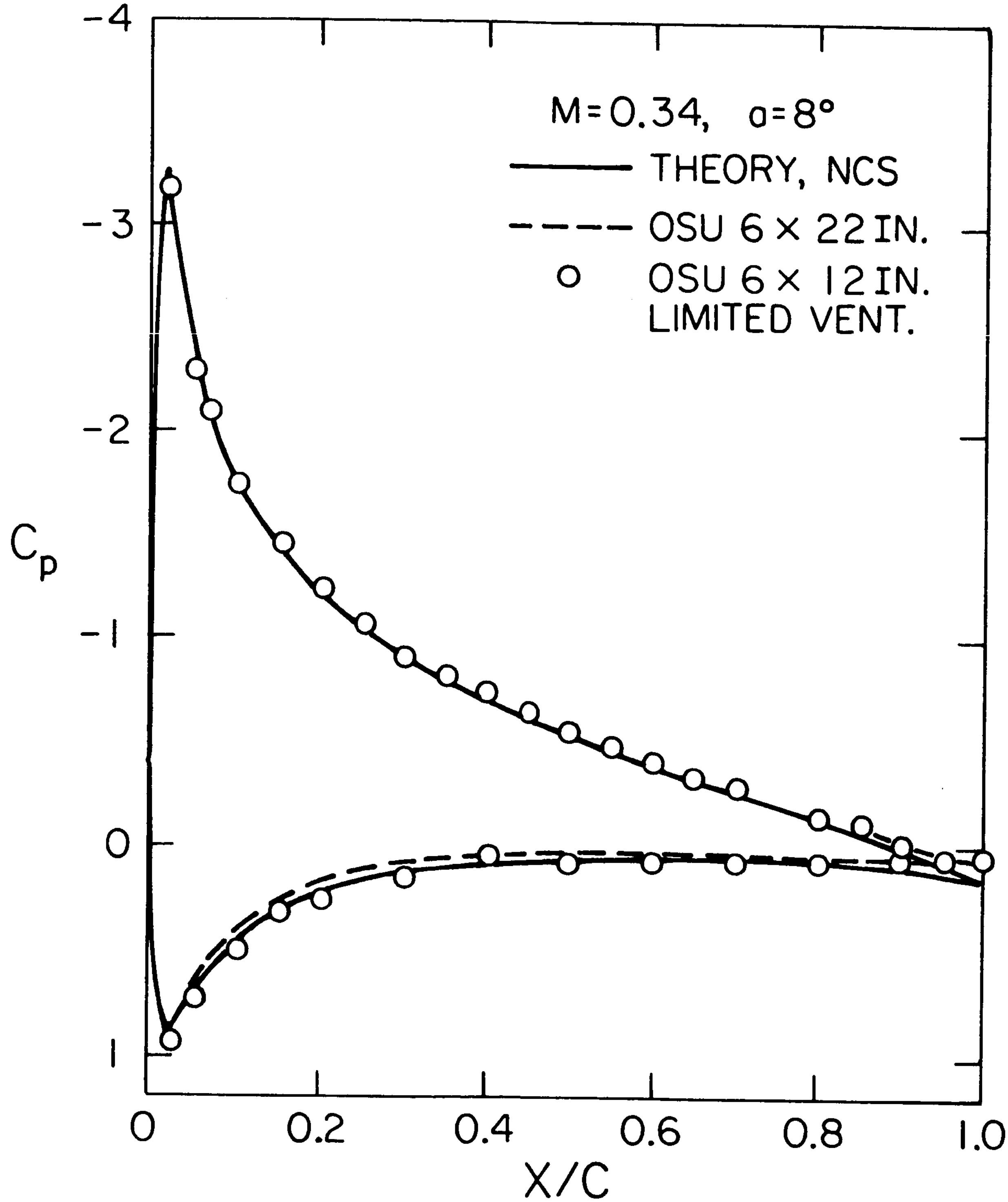

FIGURE 5. SUBCRITICAL DATA FROM OSU 6 X 12 IN. TUNNEL WITH LIMITED VENTILATION PANELS COMPARED WITH OTHER DATA AND THEORY. NACA-0012,CHORD=6 IN.

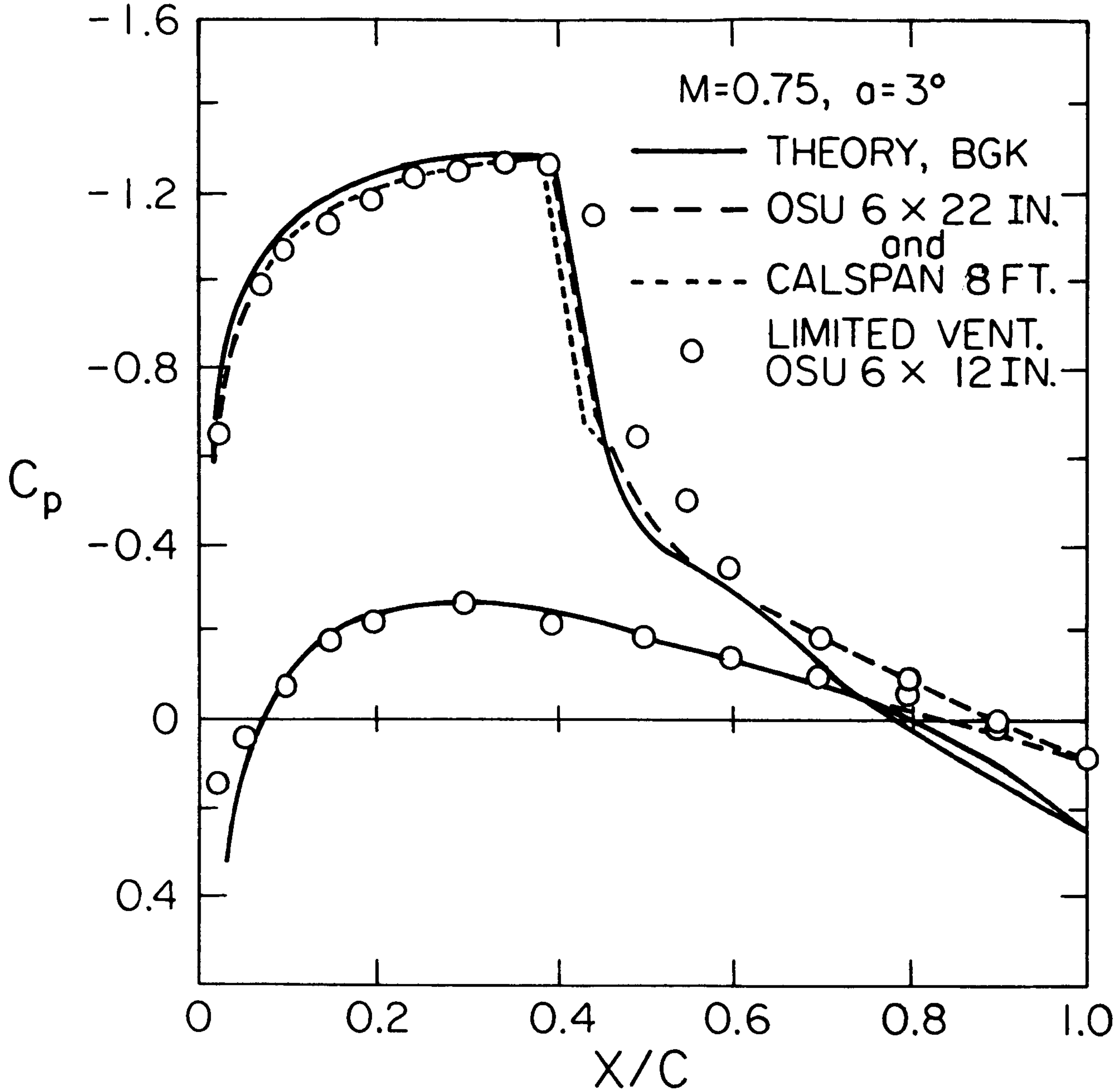

FIGURE 6. SUPERCRITICAL DATA FROM OSU 6 X 12 IN. TUNNEL WITH LIMITED VENTILATION PANELS COMPARED WITH OTHER DATA AND THEORY. NACA-0012, CHORD=6 IN.

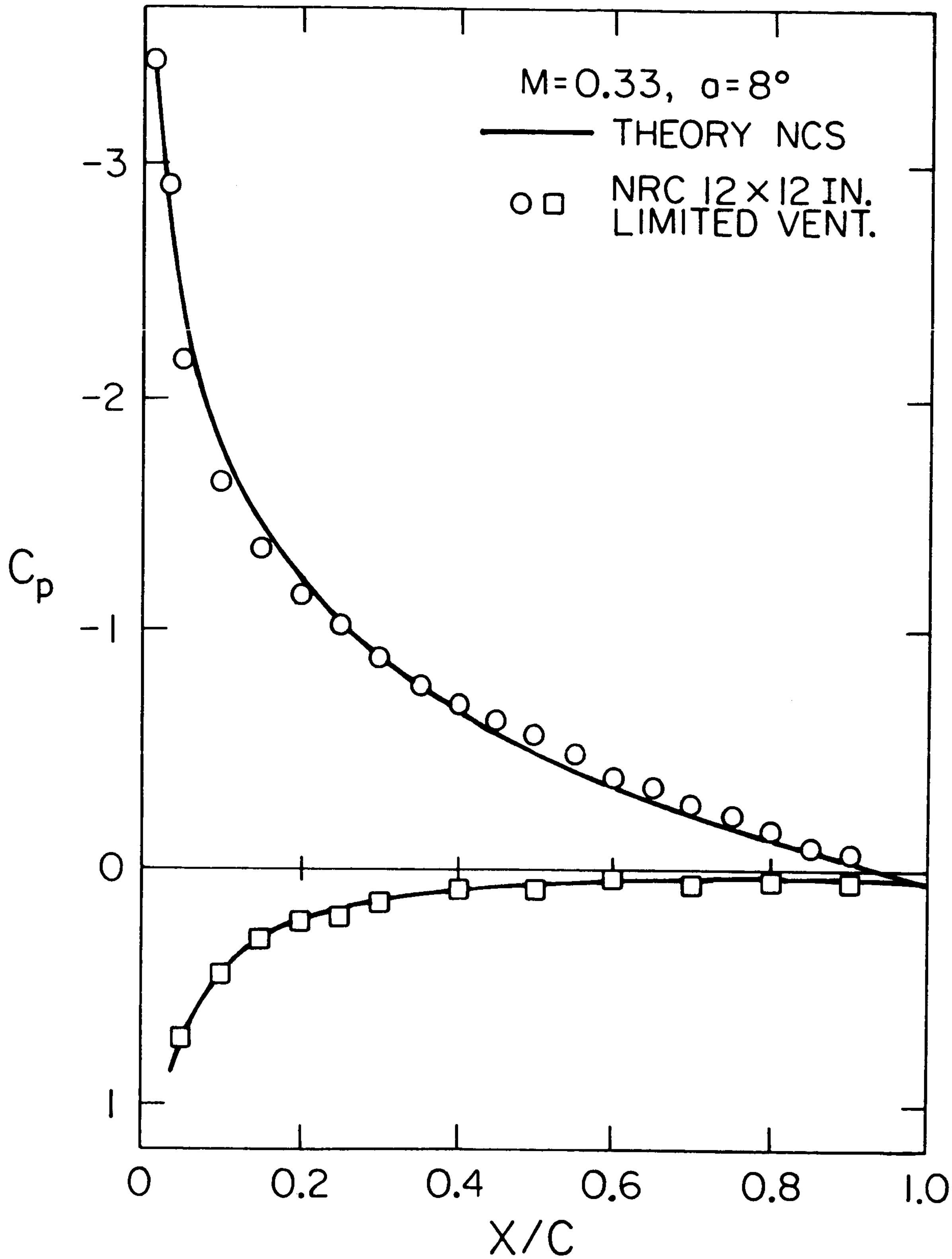

FIGURE 7. SUBCRITICAL DATA FROM NAE 12 X 12 IN. ICING TUNNEL WITH LIMITED VENTILATION PANELS. NACA-0012 PROFILE, CHORD=6 IN.

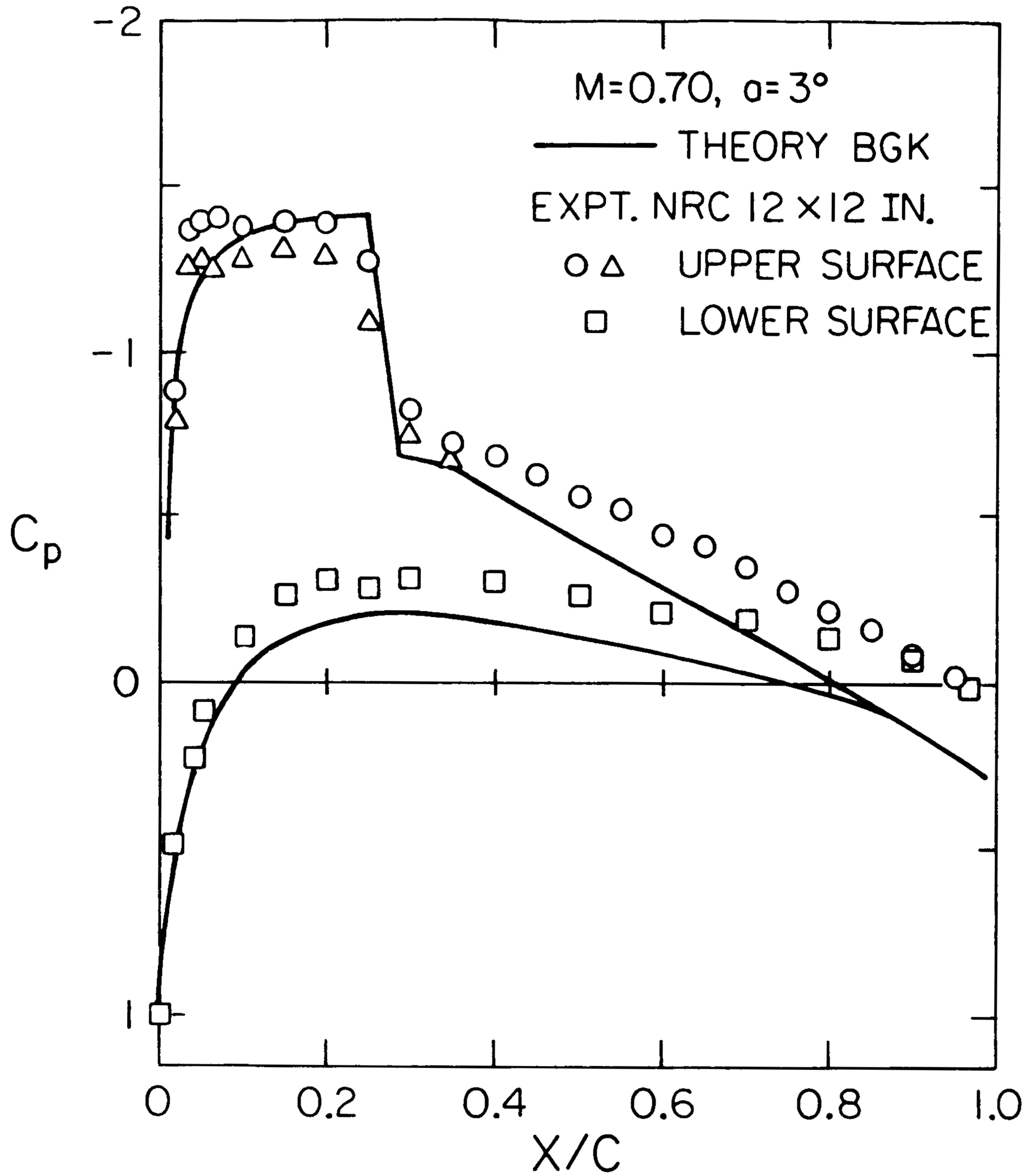

FIGURE 8. SUPERCRITICAL DATA FROM 12 X 12 IN. ICING TUNNEL WITH LIMITED VENTILATED PANELS. NACA-0012 PROFILE, CHORD=6 IN.

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16. Abstract

In two wind tunnels used for two-dimensional airfoil tests, each wall above and below the model was modified by replacing small segments of the solid boundaries with perforated plates vented into sealed chambers. Perforated segments having approximately 40 percent open area were found to reduce the transonic wall interference to a negligible level, for a model chord-to-tunnel height ratio of 0.5. This report describes the physical arrangement and presents typical model pressure distributions to illustrate the effectiveness of the technique.

17. Key Words (Suggested by Author(s))

Transonic wind tunnels; Wall interference; Aircraft icing

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